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AIRBORNE WARNING AND CONTROL SYSTEM (AWACS) INTELLIGENT TUTORING SYSTEM (ITS)

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This paper has been reviewed and is approved for publication.

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13. ABSTRACT *(Maximum 200 words)*

Researchers in the Aircrew Evaluation Sustained Operations Performance (AESOP) facility of the Crew Systems Directorate, Armstrong Laboratory (AL/CFTO) developed the capability to run realistic Airborne Warning and Control System (AWACS) scenarios, initially for performance measurement of trained Weapons Directors (WDs). Subsequently, in cooperation with the Technical Training Research Division of the Human Resources Directorate, Armstrong Laboratory (AL/HRT), Systems Research Laboratories, Inc. (SRL) developed, as a proof of concept, an Intelligent Tutoring System (ITS) for Air Force WDs.

Current human instructor-based training was observed and analyzed, instruction materials were obtained, and criteria were developed. The resulting design of the ITS consists of the AWACS simulation system, the knowledge domain, the instructor model, the student model, and an intelligent interface linking them. Though not fully implemented for this proof-of-concept effort, it is planned that each of these elements be tailored to suit the purposes of an ITS for AWACS WDs. Prior to Lesson One, the student completes a skills assessment module to establish a skill level ranging from novice to master. Software was developed to present Lesson One. Evaluation occurs at the end of the lesson. Recommendations for future development are presented.

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AIRBORNE WARNING AND CONTROL SYSTEM (AWACS) INTELLIGENT TUTORING SYSTEM (ITS)

BACKGROUND

The United States Air Force (USAF) at Tinker AFB, Oklahoma, trains USAF officers as Weapons Directors (WDs) to serve aboard the E-3B/C Airborne Warning and Control System (AWACS) aircraft. The AWACS platform supports Command, Control and Communications (C^3) missions in the airborne environment. Armstrong Laboratory, Crew Technology Division, Sustained Operations Branch (AL/CFTO), in cooperation with Systems Research Laboratories, Inc. (SRL), configured WD crewstations and affiliated systems in the Aircrew Evaluation Sustained Operations Performance (AESOP) facility to run defensive counter air (DCA) mission simulations. Teams of three WDs detect, identify, intercept, and destroy enemy aircraft attempting to attack friendly forces or penetrate friendly airspace. A Senior Director (SD) serves as the immediate supervisor in the chain of command. In a DCA mission, the SD oversees and coordinates WD efforts to execute the directives of the senior battle staff.

In cooperation with the Technical Training Research Division, Human Resources Directorate, Armstrong Laboratory (AL/HRT), SRL began research and development of an Intelligent Tutoring System (ITS) in the Air Force Specialty Code (AFSC) 17XX C^3 domain. The effort was to provide a proof of concept, with recommendations for future development.

DEVELOPING CRITERIA

One of the first tasks was to narrow the instructional domain. The following criteria were established:

1. The domain was restricted to that of weapons controllers: WDs, SDs, Weapons Controllers (WCs), and Weapons Assignment Officers (WAOs).

2. Due to practical limitations on equipment and funds, interactive voice communications were not included.

3. The domain included areas that would fill an immediate need of the Air Force's 17XX operational training community.

4. The domain was limited in order to accomplish development in the time available.

5. The ITS was restricted to Initial Qualification Training (IQT). By focusing on initial training, changes in performance would be more dramatic and, therefore, easier to measure.

6. Finally, in order for the ITS to teach something more than a routine procedure, we wanted to incorporate some decision-making skills.

Using these criteria, training systems at Tyndall AFB and Tinker AFB were deemed appropriate for adapting to an ITS. At Tyndall AFB, all 17XXs receive their initial Air Force training in the weapons controller career field. After graduating from Tyndall's introductory course, some 17XXs continue to Tinker for initial WD training in AWACS.

After initial contacts with training sites, we chose to focus on Tinker's AWACS community. After a fact-finding trip to Tinker AFB (11-13 August 1991), the main subject area for initial development was identified as *Block I, AWACS WD Initial Qualification Training.* Appendix A lists the topics and switch actions covered in Block I during the first 13 days of WD training at Tinker AFB. This list is taken from the Initial Qualification Training Reading Guide (6 June 1990). This list is an introduction to the switch actions a WD uses in performance of job tasks. Block I IQT met the first five criteria for developing an ITS. The Director of Operations of the 552d Tactical Training Squadron also indicated that an ITS for this instructional block would widen a traditional training bottleneck for AWACS WD training, thus fulfilling criterion # 3.

Criterion # 6, decision-making skills, was not met. However this criterion was of a lower priority for two reasons. First, only Block I IQT WD instructional materials were set and the AWACS WD training program was being rewritten to take into account lessons learned from Desert Shield/Storm. Second, there is an ongoing reorganization by the Air Force in the training of 17XXs.

PREPARATION

While at Tinker, SRL tried to ascertain how Instructor WDs (IWDs) taught and evaluated IQT WD students--particularly as related to Block I IQT WD training. Important findings included:

1. Time for task completion is ill-defined in early instructional blocks.

2. Number and types of errors are also ill-defined.

3. Window for task completion, while not critical at first, rapidly becomes more important than time for task completion. The size of the window remains ill-defined.

4. Fighter Weapons School is considered more important for good experience in initial categorization of student abilities and capabilities than any other prior experience.

5. Students are not accelerated through training, even if they show exceptional skill or aptitude.

6. Prior experience and training records play a part in evaluating students, but as an exception, not a rule.

7. Only some IWDs used a dual-tracking task in training of Block I IQT WDs, but this technique was being institutionalized as part of the formal program. The dual-tracking task consists of a single piece of symbology on a single track in an oval orbit. The student is required to keep the symbology on the track throughout the lesson and while performing the procedures. This dual-tracking task is not objectively measured, but subjectively indicates to the IWD that the student WD learned the lesson well.

8. Most switch actions are taught and used for two simulations in a row, and then not trained or used until a student progression test is administered.

9. Most student evaluation is subjective.

BENEFITS OF AN ITS

ITS can eliminate or ameliorate many obstacles to efficient and effective training, including those previously mentioned. ITS can take full advantage of quantitative measures developed in cooperation with expert IWDs, allow individually paced escalation of complexity and volume of tasks, and implement consistent application of evaluation criteria. In addition:

- ITS allows better use of manpower by enabling an IWD to manage the training of many student WDs rather than two or three. At the same time, ITS effectively allows a one-to-one student-to-teacher ratio.

- Because of the self-paced aspect of ITS, training can proceed at a faster rate for more able or experienced students and allow less able students ample practice time and opportunities to hone their skills.

- As the need for rapid response escalates, a WD must increase the work pace. This increase can occur only where there is spare capacity. The optimum area for this increase is that of console operations. ITS can objectively judge this spare capacity and thereby enhance WD training by developing high-performance knowledge and skills in console operations. ITS simulations can foster achievement of these skills through "consistent practice" (Regian, 1990).

- ITS allows a student WD to consistently build on recently acquired knowledge and skills rather than moving on to other tasks before these new skills are reinforced.

DESIGNING THE ITS

ITS Paradigm

The second task under this effort required the creation of a conceptual paradigm of an ITS. The five important elements that must be related to each other are:

- a Simulation System,
- a Knowledge Domain,
- an Instructor Model,
- a Student Model, and
- an Intelligent Interface that links them together (Burns & Parlett, 1990).

These elements are graphically represented in Figure 1.

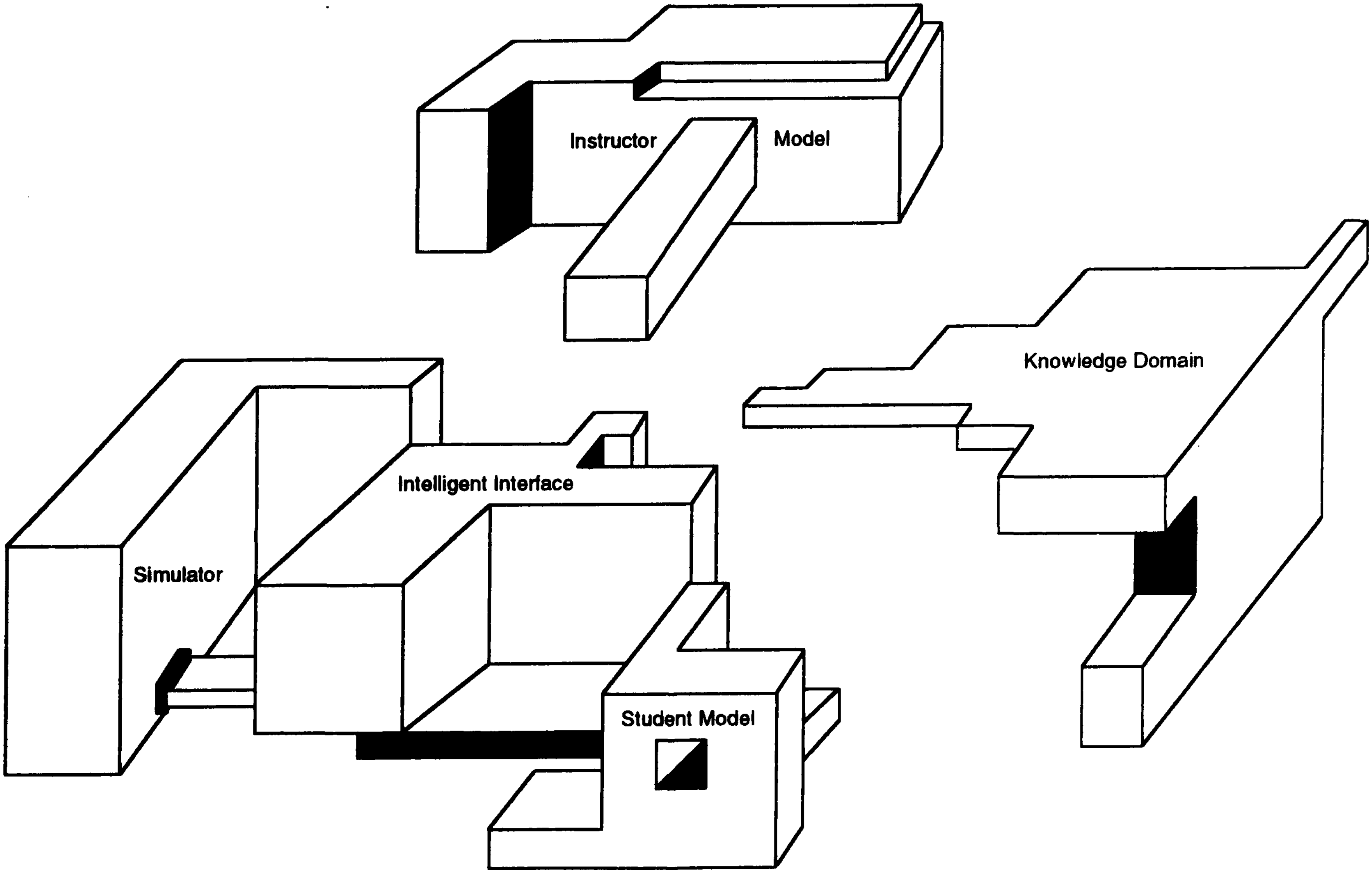

Figure 1. Intelligent Tutoring System Paradigm.

Each of these five elements is interrelated to the others. A development in one element often requires a corresponding development in one or more of the others to remain linked as a coherent whole. For example, the procedural steps for executing the Commit switch action must be included in the relevant Knowledge Domain. The capability for this switch action must exist on the simulator. The Instructor Model must indicate how, when, and where in the course of instruction to teach the *Commit* switch action. The how, when, and where of the instruction depends heavily on the Student Model. The Intelligent Interface must make the match of the Student Model to the student, pick the correct format of instructions for the lesson, execute the lesson on the simulator, and evaluate the student's progress.

Knowledge Domain

For practical reasons, the Knowledge Domain element comes first. Specifically, this element identified as the 552 AWACW IQT WD Block I, *Weapons Director Student Study Guide, Volume 1,* of training course E3000BQODX. This guide introduces students to AWACS, the WD Multi-Purpose Console (MPC), and several switch actions, building a declarative knowledge base and a procedural knowledge base. The emphasis is on procedural knowledge base (i.e., how to perform certain WD switch actions). A specific list of these switch actions was provided by a representative[1] of the 552 AWACW/DOQMW office, which is responsible for the training course development at Tinker AFB for WDs.

Simulation System

The next element, the Simulator, is well developed. C^3 Generic Workstations (C^3GWs) and the supporting AWACS Simulation software in the AESOP facility (Schiflett, Strome, Eddy, and Dalrymple, 1990) present the AWACS simulation. Most of the switch actions taught in Block I at Tinker AFB are available on the C^3GWs. The following Block I switch actions have not yet been implemented on the C^3GWs:

Restricted Area
RN/DES/NTN SD
Add/Delete Airbase
Area Define/Delete
Corridor IFF SD
Radar/IFF Tracking

These switch actions amount to 28% of the switch actions taught in Block I, IQT WD training. An estimated 280 h of programming development are needed to fully

[1] Personal communication from Capt. Fowler

develop these switch actions. In all other respects, the Simulator element closely emulates the presentation and functions of an AWACS WD MPC.

Instructor Model

The Instructor Model element contains instructional goals, accounts for student attributes, structures the Knowledge Domain, and presents the structure. Specifically, these goals are to teach the student:

1. The physical layout of the MPC (i.e., where the switch action buttons are located).

2. The procedural steps for executing MPC Console Checkout.

3. The procedural steps for executing the following switch actions:

Assign Console	TD Index
Line	Circle
Coordinate	Tactical Bearing & Range
Restricted Area	Bearing and Range
RN/DES/NTN SD	Initialize Special Point
Add/Delete Airbase	Area Define/Delete
Locate SIF	Corridor IFF SD
Request SIF	Initiate
Mode IV	Reinitiate
Radar/IFF Tracking	Assign/Defer
Request/Assign IFF/SIF	ADS Panel Channel activations

The goals lay the foundation for evaluating the student's performance. Acceptable execution of these procedures by a student WD indicates successful transfer of knowledge. However, defining acceptable execution includes several measures:

- time of complete task execution,
- time of execution of each step within the task, and
- a time window for accepting task start and end, error toleration, and alternate step sequencing, when it exists.

The values that address these measures are not currently known with certainty. Therefore, our initial set of values for evaluation was determined by a Subject Matter Expert based on years of experience as a WD/SD/IWD. The set of values chosen for different students is based on student attributes.

Student Model

Accounting for student attributes requires recognizing appropriate student differences, setting appropriate goals based upon these differences, and then selecting a mode of instruction that best matches both the student and the instructional goals. Recognizing appropriate student differences relies heavily upon the Student Model. A WD student is matched to the appropriate type in the Student Model. Once the student type is known, then the Instructor Model has the correct set of instructional goals for that student type. The prototype ITS has only one set of instructional goals based on the lowest level of student type. Selecting a mode of instruction impacts how the Knowledge Domain is structured and how information is presented.

NECESSARY WD KNOWLEDGE/SKILLS

There are three distinct, but interrelated areas of knowledge and skill necessary to be a functioning and qualified AWACS WD. These areas are declarative knowledge, procedural knowledge (Barr & Feigenbaum, 1982; Anderson, 1988), and operational skills.

Knowledge about the system, its purpose, components, events, and the relationships among them is defined as *Declarative knowledge.* Examples include how radar works, the different types of intercept geometry, air power doctrine, and brevity code words.

Procedural knowledge deals with how to operate the equipment. Examples include reading scope presentations, talking and listening by means of the communications equipment, and executing switch actions.

Operational skills encompass knowledge at both cognitive and meta levels (Chu & Mitchell, 1991). At the cognitive level, the WD must acquire some high level skills to cope with the demands of a complex task environment to properly apply the declarative and procedural knowledge in both normal and abnormal problem solving situations (Woods, 1988). Time management and cost-benefit analysis are two skills necessary for the proper coordination of multiple WD tasks in a complex and dynamic environment, with system events competing for the operator's attention. Other critical skills resulting from the dynamic, complex nature of the system include adaptiveness and disturbance management that are common to other complex systems. Two skills that are critical to the WD world include dichotic listening and three-dimensional spatial orientation with motion of objects while remaining stationary.

Meta skills concern knowledge about how to learn effectively. The body of knowledge the novice WD must learn can be overwhelming. Consequently, at the meta level, the WD needs to know how to monitor the learning process and manage different activities to get the most out of training.

The declarative and procedural knowledge together form the knowledge domain the operator must have. Operational skill can be viewed as the operator's successful acquisition and application of the knowledge domain during training that transfers to the actual task environment.

Skill Levels

In each of the three areas, a WD is rated on a scale of 1-5, with 5 being the highest. Each numerical rating corresponds to a label ranging from 1-Naive, 2-Novice, 3-Journeyman, 4-Expert, and 5-Master. The following is a description of each category:

1 NAIVE: Indicates a complete lack of knowledge and/or skill.

2 NOVICE: Has some knowledge and/or skill, but not enough to operate independently to complete assigned tasks in a timely manner. Does not recognize all patterns of stimuli. Does not know how to order behavioral actions in response to recognized patterns of stimuli.

3 JOURNEYMAN: Has enough knowledge (score 85% or better in written exams) and/or skill to operate independently to complete assigned tasks, but not always in a timely manner. Recognizes common stimuli variable patterns and applies domain rules of behavioral responses. Does not recognize situations in which the domain rules do not apply, and/or in which new variables or patterns exist. Perseveres in attempting to apply what is known. Not yet capable of solving difficult or complex problems or developing new rules.

4 EXPERT: Has superior knowledge and/or skill. Operates well independently to complete all assigned tasks in a timely manner. Recognizes common stimuli variable patterns and applies domain rules of behavioral responses. Recognizes existence of new variables and/or situations in which the domain rules no longer apply, and can usually develop a solution. Capable of solving most difficult or complex problems.

5 MASTER: Has superior knowledge and/or skill. Operates well independently to complete all assigned tasks in a timely

manner. Recognizes common stimuli variable patterns and applies domain rules of behavioral responses. Recognizes existence of new variables and/or situations in which the domain rules no longer apply, and can develop new rules. Capable of solving difficult or complex problems.

The goal of the training in Block I AWACS WD training is to bring all students up to the NOVICE/level 2 for Procedural Knowledge, Declarative Knowledge, and Operational skill.

COURSE STRUCTURE

Since the Knowledge Domain consists largely of Procedural Knowledge, the required step sequences are already structured. Yet there is a need for a comprehensive course outline that addresses the goals of Procedural Knowledge to be taught in each lesson, how many lessons there will be, and how fast the pace of presentation will be. The course outline is currently taken from the list of switch actions provided by the 552 AWACW/DOQMW office and the IQT-WD Reading Guide. The maximum time allowed for the course is specified, but no minimum time is established.

Student Skills Assessment

For this proof of concept prototype, we developed a Student Skills Assessment module to categorize student WDs (from 1-Novice to 5-Master) according to experience and ability. This module consists of an Experience Questionnaire and a Switch Action Exercise that students complete on the console prior to the first lesson. A printed copy of this questionnaire is included as Appendix B. Although it is highly probable that the students taking this course are novice WDs just graduated from the introductory course at Tyndall AFB, exceptions occur with sufficient frequency that they must be addressed. For example, occasionally a student may have extensive experience either as a WD or as an aircraft controller and must be requalified as required by regulations. The multiple-choice questionnaire ascertains the same information usually gleaned from the student's records or informally gathered by the instructors during the lesson breaks. In addition, where the student indicates a proficiency above basic entry level, the Switch Action Exercise is presented to validate the evaluation. The normal Lesson One, Block I instruction is then presented.

The first lesson consists of three parts and is presented at only one pace of instruction. The Instructor Model does not evaluate the student during the lesson, only after the lesson is complete. The capability to evaluate the student during the lesson and the capability to change the lesson mode, if necessary, need to be more fully developed.

Lesson One

The Simulator Model is the means of instructional presentation and includes five phases of instruction in this high performance Knowledge Domain (Fink, 1990):

(1) Static overview knowledge,

(2) General procedure-oriented knowledge,

(3) Guided example exercises,

(4) Unguided example exercises, and

(5) Automated example exercises.

Static overview knowledge consists of a general description of the salient parts and features of the particular piece of equipment on which the task will be performed. This static overview is not included in the prototype. Instead, it is left to the written material found in the IQT WD Student Study, Vol. I.

General procedure-oriented knowledge consists of a description of the steps that must be performed in executing the procedure being taught. Parts of the equipment involved and the motivation or effect for each step are indicated. Each of the lessons should start here for the lowest level student. The first part of Lesson One describes the steps and indicates where the switches are. It doesn't give any motivations for each step or each step's effect on the overall status of the goal.

Guided example exercises provide the student with the opportunity to practice with specific examples while being prompted and coached in order to develop accuracy in the skill. The second part of Lesson One presents a procedure the student must perform on the Simulator. Instructions guiding the student are presented, but the student is not evaluated during the lesson.

Unguided example exercises provide the student the opportunity to practice the whole process with specific examples without interruption in order to develop speed with accuracy. These exercises comprise the third and final part of the Lesson One. The student is given 10 min to execute the Console Checkout while reading and following the Console Checkout checklist. After 10 min, the lesson is terminated and the data on student performance is gathered and evaluated. In future ITS development, this process should be automated.

Automated-example exercises provide the student the opportunity to practice the entire process with specific examples while doing another task. These types of exercises allow the WD to develop the capability to perform tasks automatically. The first lesson is not designed to use this phase. However, Console Checkout is done at the beginning of each and every lesson. As the lessons proceed, the time for this procedure's completion will narrow down from 10 min to 3 min.

DEVELOPING THE SOFTWARE

The development of this prototype was accomplished with a minimum amount of coding change to the existing AWACS Simulation software. Rather than having the two pieces of software integrated, the ITS software executes as a separate process from the simulation, but uses the data collected in the Logger File as input for evaluation. The intent is to have both pieces of software execute in an alternating fashion so the results of one can be used in the next execution of the other. Hence, the ITS software brackets the simulation to provide the appearance of an imbedded simulation without actually accomplishing the imbedding process. On the front end, the ITS software provides the interaction necessary to instruct and evaluate the student before selecting an appropriate scenario for the AWACS Simulation. Then on the back end, the ITS software evaluates the student's performance during the simulation before presenting the appropriate follow-on instruction area.

Admittedly, using two computers systems to provide the functionality for the AWACS ITS is not the ideal solution. However, it does provide a flexible test platform upon which to develop some quantitative metrics for estimating the skills of the student WD. While pedagogy suggests the development of high-performance skill is best accomplished via consistent practice, establishing the criteria to judge the WD student still requires significant amounts of definition and refinement.

AWACS ITS PROGRAM DOCUMENTATION

The software for the AWACS ITS was developed on both the UNIX based Silicon Graphics (SG) 4D/50 and the DEC VAX 780 computers using *C* and the *Curses* screen handling package. With the exception of the simulation graphics (SG only), all user interaction can be accomplished using either the SG graphics or DEC VT200 series terminals.

The AWACS ITS operates as three separate parts:

1. The SG 4D/50 software provides the instructional capability for the ITS.

2. The Simulation software provides the hands-on aspect of the WD's console operation.

3. The VAX 780 software is the first iterative trial to evaluate a WD's actual console operation.

SRL provided program documentation for the AWACS ITS software in contract deliverables to USAF Armstrong Laboratory, Crew Technology Division, Sustained Operations Branch (AL/CFTO).[2] An ITS User's Guide is included as Appendix C of this paper.

RECOMMENDED DEVELOPMENT

After successfully completing the proof-of-concept, several areas could be further developed depending on future funding levels. The following are suggested refinements to the existing software:

1. Besides determining the start and stop of each switch action, each of the associated switch-checking modules could be made considerably more intelligent (e.g., devise methods of linking such things as time delays and erroneous inputs with help messages and switch menus). This development would, in effect, provide an interim capability for both the student and instructor to review performance.

2. Provide a better prompt for Control key paging functions. This procedure may entail just displaying paging options in appropriate places on the screen, i.e., **Ctrl-P, up-arrow, Ctrl-B** at the top of the screen and **Ctrl-N, down-arrow, Ctrl-F** at the bottom of the screen.

3. Options to develop:

   a. Establish criteria for those values that are to be scored and stored.

   b. Provide a mechanism for the student to review material and answers, but preclude the capability to change original values.

   c. Establish criteria for demotion, promotion, or instructor intervention based upon scores.

4. Build a utility to assist in the development of a lesson and/or instruction block so the instructor's attention can be focused on content and not procedure.

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[2] Systems Research Laboratories, Inc.: "Research and Development Computer Software Report, Delivery Order 0008, Attachment 2, Sequence 1," Contract No. F33615-87-D-0601, September 1990.

While these changes would significantly improve the system's usability, additional development is required to produce a fully functional AWACS ITS. These improvements should include:

1. Integrate the AWACS Simulation and ITS software into a single package so that it will qualify as an expert system that is limited to switch action procedures. This limitation obviates the knotted problems that are often associated with the inclusion of strategy.

   For the start of this effort, the current ITS operation will be continued, i.e., maintain execution in batch fashion, and improve the software so it can reliably detect the beginning and ending responses to events. In turn, each established detection scheme will be coded into the Simulation software so that the end result should be the limited expert system that is desired.

2. Using the just described, limited expert system as a kernel, this development would add the capability to detect and suggest solutions to switch action procedural problems while the Simulation is running.

   With the knowledge that the Simulation software controls the scenario presentation to the student and that it can now determine the correctness of switch action procedures, it is now possible to determine the appropriateness of proffered switch action procedures in response to controlled scenario situations. This development would allow the software to passively monitor a student's actions and provide real-time diagnostics as procedural errors occur.

3. Incorporate a reactive Instructor and Student Model into the software that was developed during Step 2.

   Since the software can now monitor a student's switch actions to known situations, this would begin the development of both the Instructor and Student Model software. Essentially, the software will be given the capability to evaluate a student and determine whether the student requires either advancement, remediation, or to be kept at status quo. These software decisions will be based upon actions that were taken. Consideration of actions that were omitted will be avoided unless outcomes are blatantly obvious.

REFERENCES

Anderson, J. R. (1988). "The Expert Module." In M. C. Polson and J. J. Richardson (Eds.), Foundations of Intelligent Tutoring Systems. Hillsdale, NJ: Lawrence Erlbaum Associates.

Barr, A. and Feigenbaum, E. A. (1982). The Handbook of Artificial Intelligence, Vol. II. Los Altos, CA: HeurisTech Press.

Burns, H. and Parlett, J. (1990). " The Dimensions of Tomorrow's Training Vision: On Knowledge Architectures For Intelligent Tutoring Systems." In Burns, H., Luckhardt, C., and Parlett, J. (Eds.), Proceedings of the Second Intelligent Tutoring Systems Research Forum, AFHRL-TP-89-31. San Antonio, TX: Air Force Systems Command, Air Force Human Resources Laboratory, Brooks AFB.

Chu, R. W. and Mitchell, C. M. (1991). "A Pedagogical Design and Architecture for Intelligent Tutoring and Aiding in Supervisory Control of Complex Systems." In NASA Conference Publication 10100, Vol. 1, Proceedings of the Contributed Sessions 1991 Conference on Intelligent Computer-Aided Training, p. 39.

Fink, P. K. (1990). "Issues In Representing Knowledge For Training High Performance Skills." In Burns, H. L., Luckhardt, C., and Parlett, J. (Eds.), Proceedings of the Second Intelligent Tutoring Systems Research Forum, AFHRL-TP-89-31. San Antonio, TX: Air Force Systems Command, Air Force Human Resources Laboratory, Brooks AFB.

Regian, W. J., "Representing and Teaching High-Performance Tasks Within Intelligent Tutoring Systems," Proceedings of the Second Intelligent Tutoring Systems Research Forum, Hugh L. Burns, James Parlett, and Carol Luckhardt (Eds.), Brooks AFB, TX, AFHRL-TP-89-31, April 1990, p. 15.

Schiflett, S. G., Strome, D. R., Eddy, D. R., and Dalrymple, M. A. (1990). Aircrew Evaluation Sustained Operations Performance (AESOP): A Triservice Facility for Technology Transition, USAFSAM-TP-90-26. San Antonio, TX: Air Force Systems Command, Human Systems Division, Brooks AFB.

Systems Research Laboratories, Inc.: "Research and Development Computer Software Report, Delivery Order 0008, Attachment 2, Sequence 1," Contract No. F33615-87-D-0601, September 1990.

Woods, D.D. (1988). "Coping with complexity: The psychology of human behavior in complex systems." In L. P. Goodstein, H. B. Anderson, and S.E. Olsen (Eds.), Tasks, Errors and Mental Models. London: Taylor & Francis.

Appendix A

IQT Block I

Topics and Switch Actions

Day 1	Familiarization and Mechanics Assign Console TD Index Hardcopy TD Update
Day 2	Line Circle Coordinates Arrow Message
Day 3	Winds Aloft TD Airbase Weather TD Initialize Special Point RN/DES/NTN SD
Day 4	Identifying Tracks Initiate Reinitiate Mode IV Drop Assign/Defer Request SIF Locate SIF
Day 5	Track Blocks Track TDs/Special Point TDs
Day 6	Radar/IFF Tracking Request/Assign IFF/SIF Area Define/Delete Corridor IFF SD
Day 7	RCT Initialization TD Add/Delete Airbase Commit Cap RTB Alter Control

Day 8	RCT Mission/Augmented Msn TD Manual Guidance Fuel/Configuration Armament Update/Override Command Tracking RCT Mode Control Aircraft Down
Day 9	Mission Modifier Recovery Airbase Beam Rider Bearing and Range Tactical Bearing and Range
Day 10	Order of Battle Add/Delete Order of Battle SD Restricted Area Present Altitude Target Altitude
Day 11	Intercept Line SD MA/Kill UHF Tune WT Handover Accept/Reject Handover Wilco/Cantco
Day 12	Review All Block I Academics
Day 13	Written Evaluation and Critiques

Appendix B

Experience Questionnaire

EXPERIENCE QUESTIONNAIRE

1. Have you ever been Mission Ready (MR) qualified as a 17XX ?

   A. Yes
   B. No

2. Were you MR as a _____?

   A. U.S. or NATO E-3 WD/IWD/SD/ISD
   B. U.S. or NATO E-3 ASO
   C. Other

3. You are here because ________.

   A. You've been DNIF for more than 180 days.
   B. You failed an EVAL and are being retrained.
   C. You've only been NATO qualified.

4. Do you have any other 17XX experience ?

   A. Yes
   B. No

5. Your other 17XX experience includes ________ .

   A. MCE
   B. 407L CRC/CRP WC/WAO
   C. 407L CRC/CRP ASO
   D. NORAD/ICELAND/ALASKA ROCC/SOCC WC/WAO
   E. NORAD/ICELAND/ALASKA ROCC/SOCC ASO
   F. Manual Radar (FACP/TSP-43E)
   G. Other

6. Does your other 17XX experience include a stint as an exchange officer with the U.S. Navy in the E-2C ?

   A. Yes
   B. No

7. Did you graduate from Tyndall's Basic WC Course (E30BP-1741A-004)?

A. Yes
B. No

8. Were you ______ ?

A. a Distinguished Graduate
B. in the top 25% of your class
C. average
D. barely passed

9. Did you take the automated course?

A. Yes
B. No

10. Were you prior enlisted?

A. U.S. Air Force
B. U.S. Navy
C. U.S. Army
D. U.S. Marine
E. No

11. Are you a former 16XX ?

A. Yes
B. No

12. While you were prior enlisted in the Air Force, did you have the AFSC _______ ?

A. 11XXX
B. 276XX
C. 30XXX (Air Traffic Controller at a RAPCON)
D. Other

13. While you were prior enlisted in the Army, did you have a previous job as ____ .

A. Helicopter pilot
B. Fire control officer for Patriot or I-HAWK battery
C. Radar Air Traffic Controller
D. Joint Stars operator
E. Other

14. While you were prior enlisted in the Navy, did you have a previous job in _____ .

A. Radar Air Traffic Control
B. Air Intercept Control
C. Other

15. While you were prior enlisted in the Marines, did you have a previous job in _________ ?

A. Radar Air Traffic Control
B. Air Intercept Control
C. Other

16. Are you an exchange/liaison officer from _________ ?

A. the U.S. Army
B. the U.S. Navy
C. the U.S. Marines
D. another nation

17. In the U.S. Army, your previous jobs included _______ .

A. Pilot
B. Joint Stars
C. Air Defense Artillery
D. Radar Air Traffic Control
E. ASOC (Air Support Operations Center)
F. Other

18. In the U.S. Navy, your previous jobs included _______ .

A. Pilot
B. Radar Intercept Officer
C. E-2C Naval Flight Officer
D. Radar Air Traffic Control
E. Air Intercept Control
F. Other

19. In the U.S. Marines, your previous jobs included ______ .

A. Pilot
B. Air Defense Artillery
C. Radar Air Traffic Control
D. F-4 Weapons System Operator (WSO)
E. MACS 5/6/7 Radar Control/Air Intercept Control
F. Other

20. You are a _______ officer.

A. United Kingdom
B. Canadian
C. French
D. German
E. Other

21. You have experience in/as _______ .

A. Pilot/Navigator
B. Weapons System Officer (WSO) in F-4/Tornado IDS
C. Schackelton AEW.2
D. NATO E-3 or UK E-3D AEW.Mk.1 ASO
E. NATO E-3 or UK E-3D AEW.Mk.1 WC/WAO
F. Other Radar Control Air Defense Work
G. Other (work not involving Radar)

22. You have experience in/as _______ .

A. U.S. E-3 ASO
B. NATO E-3 WC/WAO
C. NATO E-3 ASO
D. NORAD ROCC/SOCC
E. Ground Radar Weapons Controller
F. Other

23. You have experience in/as _______ .

A. Pilot/Navigator
B. NATO E-3 WC/WAO
C. NATO E-3 ASO
D. NADGE WC
E. Other

24. You have experience in/as _______ .

A. Pilot/Navigator
B. French E-3F WC/WAO
C. French E-3F ASO
D. Other

25. Are you a Fighter Weapons Instructor Course graduate?

A. Yes
B. No

Appendix C

ITS User's Guide

Intelligent Tutoring System

User's Guide

You may run the ITS program using a SGI terminal even though its software is spread across a SGI/UNIX and DEC/VMS based system. Functionally, the software is used as follows:

- The presentation of the questionnaire function is accomplished using only the SGI/UNIX system.
- The presentation of the Simulation is accomplished using a combination of both the SGI/UNIX and DEC/VMS systems.
- The presentation of the evaluation software is accomplished using only the DEC/VMS system.

Each function is started separately. While having to start each function is not ideal, the modularity did provide a better software development environment with no impact to the existing Simulation software.

Questionnaire Function

To begin the Questionnaire Function, you must have the "ITS Window" on the screen. This window is sized to an 80 character by 24 line (80x24) display for the presentation of questionnaire material. Enter the following command to initiate this window:

```
wsh -n 'ITS Window' -p175,300 -s80,24
```

Enter **ITS** at the prompt within the window.
ITS prompts you as follows:

1.

```
Use cursor to select:
Instructor  Student
 then press 'Enter'
```

The desired selection is highlighted on the screen.

If you select the **Instructor** option, continue with Step 2.

If you select the **Student** option, continue with Step 13.

2. At this point, nothing on the screen changes. However, ITS expects you to enter the proper password before continuing. Entry of any other value causes the program to terminate without any indication. Once you enter the proper password, continue with Step 3.

3. ITS displays the following prompt:

   Enter index of desired option:

   1. Add an instruction block
   2. Delete an instruction block
   3. Modify an instruction block
   4. Review an instruction block
   5. Review a student's performance
   6. Adjust a student's instruction

   Selection:

   Enter the desired option by specifying **1**, **2** etc.

   Note: Only options 1-3 are implemented. Selections 4-6 are not implemented at this time.

   Enter one of the options 1-3, continue with Step 4.

   Note: If you enter any value other than 1-6, ITS displays **Invalid response**. Press the **Enter** key to acknowledge and ITS displays the following message:

   Terminate ITS [Y/N]:

   If you enter any value other than **Y**, ITS interprets it as a **N** response and returns to the start of this Step. If you enter **Y**, the program terminates.

4. ITS prompts you for the specification of the path to the **Instructor** directory. However, if you have already accomplished this Step (on a previous pass through the program), ITS continues with Step 5. If not, the following display appears:

   Enter path to "Instructor" file directory
   ->

You may either specify the **Instructor** file directory or press the **Enter** key to get the default value as stipulated by **instr_path_def** in **itsdef.h**. In both cases ITS prompts you to verify the specification:

Is path correct? [Y/N/Q]:

If you enter **Q**, the program terminates.

If you enter **N**, this Step is repeated.

If you enter **Y**, continue with Step 5.

5. ITS displays titles of existing **Instruction Blocks** along with the following message:

   Use cursor to position, 'Enter' to select, or 'Q' to quit

   If you selected option 1 in Step 3, **Add an Instruction Block**, ITS displays a reminder of existing titles. For options 2 or 3, you may choose the Instruction Block that is to be modified or deleted, respectively.

   If you selected option 1 in Step 3, continue with Step 6.

   If you selected option 2, **Delete an instruction block**, ITS continues with Step 9.

   If you selected option 3, **Modify an instruction block**, ITS continues with Step 12.

6. ITS asks you to enter a title to the new instruction block:

   Enter title (max = 80 chars):

   Enter the title and continue with Step 7.

7. ITS asks you if there are any lessons associated with this Instruction Block:

    Any lessons in this instruction block [Y/N]:

    You may create the instruction block entry by entering **N** and ITS continues with Step 3, or if lessons are to be added, enter **Y** and continue with Step 8.

8. ITS displays the title of the instruction block and a numbered list of empty lesson entries, followed by the prompt:

    Enter lesson name (max = 10 char):

    Enter the names of the lessons that are to comprise this instruction block. When you have finished, terminate this Step by entering **q** to **lesson name** and ITS continues with Step 3.

9. ITS displays the title of the instruction block and a numbered list of the lessons in the block along with the following prompt:

    Do you want to delete lessons? [Y/N]:

    If you want to delete only the Instruction Block, enter **N** and ITS continues with Step 3.

    If you also want to delete lesson files, enter **Y** and continue with Step 10.

10. ITS displays the following prompt:

    Delete (a)ll or s(ome) of these lessons:

    If you want to delete **all** the lesson files listed, enter **a** and ITS continues with Step 3.

    If you want to selectively delete **some** of the lesson files, enter **s** and continue with Step 11.

11. ITS displays the following prompt:

    Enter index of lesson to be deleted:

    Enter the number that appears with the lesson name.

    Note: The numbered list is reordered after each deletion so indices can change for each specified deletion.

    When you are finished deleting, enter **q** and ITS continues with Step 3.

12. ITS displays the title of the instruction block and a numbered list of the lessons in the block along with the following prompt:

    Modifying (t)itle or (l)esson:

    If you want to modify the title of the instruction block, enter **t** and the prompt **Enter title** will overwrite the previous prompt and allow you to specify a new title. ITS continues with a repetition of this Step.

    If you want to modify a lesson, enter **l** and ITS displays the following prompt:

    Enter index of lesson to be changed:

    Enter the number associated with the lesson to be changed and ITS displays the following prompt:

    Change: (d)elete, (m)odify, (i)nsert:

    If you want to delete the selected lesson, enter **d.** ITS continues with the repetition of this Step.

    If you want to insert or modify a lesson, enter **m** or **i.** ITS displays the prompt **Enter lesson name.** Modify or Insert the lesson name and ITS continues with a repetition of this Step.

    To terminate this Step, enter **q** and ITS continues with Step 3.

13. ITS asks you to specify the path for the **Instructor** and **Student** directories. If one or both use the default values, the values for the **instructor** and **student** paths are taken from the **instr_path_def** or the **stdt_path_def** values in **itsdef.h**, respectively.

For the **instructor path**, ITS displays:

Enter path to "Instructor" file directory
->

For the **student path**, ITS displays:

Enter path to "Student" file directory
->

Both are followed by the prompt:

Is path correct? [Y/N/Q]:

If you enter **Q**, the program stops.

If you enter **N**, this Step is repeated.

If you enter **Y**, then:

a. If this response is to the **instructor path** prompt, ITS continues with a request for the **student path**.

b. If this request is to the **student path** prompt, ITS continues with Step 14.

14. ITS prompts you (the student) for identification:

Enter name and SSAN:

Name:

ITS asks you to verify identification:

Is name spelled correctly? [Y/N]

If you answer **N**, this request is repeated.

If you answer **Y**, ITS requests your Social Security Number (SSAN):

SSAN: xxx-xx-xxxx

Verify your entry by answering:

Is SSAN correct? [Y/N]

If you enter **N**, SSAN portion of the this Step is repeated.

If you enter **Y**, continue with Step 15.

15. If the student is **new**, ITS displays the following verification step:

Are you a new student? [Y/N]

If you enter **N**, ITS repeats Step 14. Otherwise, if the student is either new, as indicated by a **Y** reply, or has not completed the Experience Questionnaire, as indicated in the student's database, ITS presents the questionnaire.

At the conclusion of the questionnaire, ITS begins the Simulation. If the student is above the base entry level, then the Simulation is used to present a scenario to try and validate the determined level. Otherwise, the Simulation consists of the **Console Checkout** lesson.

Simulation Function

Documentation for the Simulation Function can be found in:

> Systems Research Laboratories, Inc.: "Research and Development Computer Software Report, Delivery Order 0008, Attachment 2, Sequence 1," Contract No. F33615-87-D-0601, September 1990.

Evaluation Function

To execute the Evaluation Function, you must be in a window with access to the VAX. It is also assumed that the student has completed a session with the Simulation. Prior to running the software to evaluate the student's performance, the data captured by the Simulation must be preprocessed so it is time ordered. This is accomplished by executing the following command on the **logger file**.

```
reduce "mindisk 0 f 1 l 6 sim 90 dir [logger file directory string] status"
go
quit
```

Upon completion of the **REDUCE** run, begin the evaluation by entering:

```
run sdt_eval
```

Processing continues with the following steps.

1. ITS asks you to specify the location of the output of the previously mentioned **REDUCE** process.

    Enter name of the data file
    Name:

    Enter the catalog/file string of the **Pass 6 logger file** from **REDUCE**. Upon completion, ITS asks you to verify that the file specified is a **REDUCE pass 6** output.

2. ITS asks you to specify the number of WDs tested:

    Enter the number of WDs that were tested:

3. ITS asks you to associate the WDs with a specific console number by answering the following query for the each WD tested:

   Enter console no. of xxx WD:

4. ITS asks you to specify the WD id number for each console that contained a tested WD:

   Enter WD id no. for console x:

   where x is substituted with the appropriate console number.

5. For this Step, ITS displays the following:

   Select skill level for evaluation:

   1) Naive
   2) Novice
   3) Journeyman
   4) Expert
   5) Master

   Selection:

   Enter an appropriate value. At this time, this value is not used. The intent is to provide multiple criteria when evaluating the scenario from a Simulation run.

6. ITS asks for the location of the event script file:

   Enter name of event script file
   Name:

   Upon answering the name of the event script file, processing continues until the event script is exhausted. As the absence or presence of each event is detected, a brief message about the condition is displayed. You must acknowledge each message with the **Enter** key before the program continues. Currently, display of the captured data is limited to the screen. However, recording these data to a file could be easily accomplished.